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C-Hole Scintillation Counter Installation and Testing

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I. INTRODUCTION

Over the shutdown period ending in November 2003, eight additional scintillation counters were installed in octants 5 and 6 of the C-layer to provide more complete muon trigger coverage and increase the muon acceptance in the bottom of the DØ detector. A complete description of the design and construction of these new detectors can be found in [1]. The purpose of this note is to give further information about the installation and testing of the C-Hole scintillation counters.

The PDT under which the detector is positioned in the DØ detector is used as the counter's designation. Also, for this note, the detectors closest to the centerline are labeled with an 'N' (for Narrow), while the outside for detectors are labeled with a 'W' (for Wide). Thus, '216N' designates the narrow counter (closest to centerline) installed under PDT 216.

II. PRE-INSTALLATION TESTING

Testing was done to determine the best high voltage at which to operate each photomultiplier tube (PMT). Due to limitations on the number of high voltage(HV) cables available from the Movable Counting House to the Collision Hall, it was necessary to group the counters into two groups operating at a single voltage setting for each group. Ideally, the nominal voltage for each photomultiplier tube would be determined by measuring the efficiency of detecting cosmic muons as a function of operating voltage, and determining the voltage at which efficiency no longer increases for further increases in voltage. This is rather time consuming, so an alternate approach was investigated in the following steps.

A. Plateau curve for a counter

First, the nominal voltage was determined for a single counter by measuring the efficiency of detecting cosmic muons as a function of PMT voltage. This was done in the following way: two trigger counters were placed immediately above and below the test counter, and output from these trigger counters were sent through coincidence circuitry to a scalar counter. The test counter output was sent to a second scalar counter. The test counter PMT was set a particular high voltage, and both scalar counters were started at the same time. When the number of hits in the trigger scalar counter was at least 100, both counters were stopped. Efficiency was taken as the ratio of the number of hits in the test counter over the number of hits coincident in both test counters.

The efficiency was measured for voltages ranging from 1875 to 2025 V in increments of 25 V. The nominal voltage was that at which efficiency no longer increased for increasing voltage.

To determine the variations from one extreme corner of the counter to the other, the plateau curve was measured with the trigger counters above and below each corner. In this way, nominal voltages were obtained for both PMTs for each corner, for a total of 8 nominal voltages.

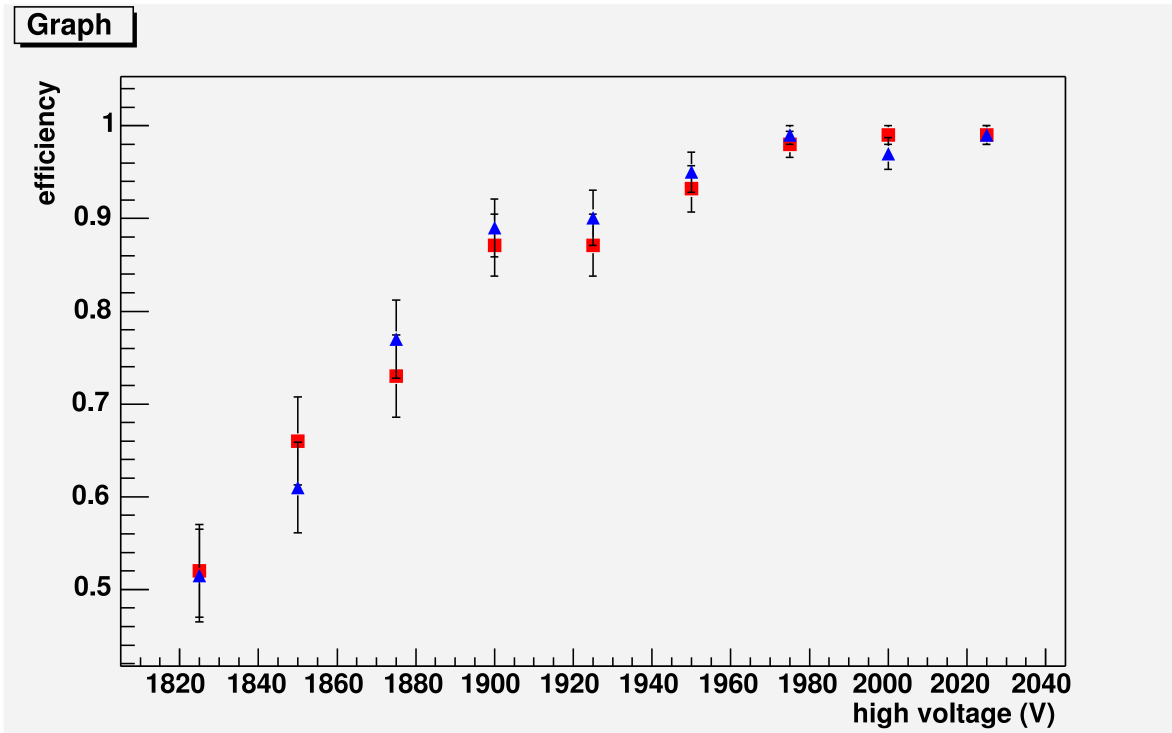

FIG. 1: Voltage plateau curve for typical counter

TABLE I: Nominal voltages measured for PMTs A and B for each corner of a counter

Position Number	PMT A	PMT B
1	1975	1975
2	2000	1975
3	1950	2000
4	1975	1975

B. Determining output voltage using radium source

Next, some measurements were taken to determine the possibility of using the a radium source to characterize the performance of the detectors. To do this, the PMT output was integrated using a 0.01 microFarad capacitor in series with the output. This output voltage was measured 8 times, once for each PMT for each corner of the counter. The radium source was placed in approximately the same position that the trigger counters had been placed for each corner, and the signal strength was measured. This was done with the PMT voltages set at the nominal voltages obtained from the plateau curves. It was found that the radium source gave about an average of 71 mV for all 8 measurements, with values ranging from 68 to 78 mV.

For the remaining counters, the voltages were varied until output signals of at least 100 mV were obtained with the radium source on each corner.

C. Further Studies and Final Nominal Voltage Determination

Having obtained the nominal voltages for each C-Hole counter, some studies were done to determine how the signal strength varies as the radium source nears the edges and corners of the counter. It was found that the signal decreases by a factor of 4 when the radium source is placed exactly on the corner (such that the center of the radium source is on the corner). Nominal voltages were remeasured to obtain voltages such that the signal is at least 30 mV above background with the radium source exactly on the corner.

Nominal voltages were raised about 100 V as a result of this study, but it is believed that the voltages are high enough to detect hits resulting from the most distant corners of the counters.

III. DETECTOR INSTALLATION

Each scintillation counter in the Central Scintillation System has 2 PMTs, and each PMT requires a high voltage (HV) cable and a signal cable. In addition to this, all scintillation counters have optical light fibers permanently connected for use in periodic testing using specially generated light pulses. These cables are running on the floor of the DØ detector from the scintillation counters directly to the nearest corners of the detector foundation. From here they are routed to the appropriate locations. Caution was required during counter installation to avoid damaging the fragile light fibers.

A. Method of installing counters

To facilitate moving the scintillation counters into their final positions, unistrut frames were constructed for pairs of detectors. Ropes were attached to each corner of the framees for use in pulling the counter pairs from either side of the DØ detector. Because the frames were not rigidly connected to the scintillation counters, care had to be taken to ensure that the frames and counters moved together at all times. Counters within each pair were connected to each other with mylar tape. This was done to avoid damage to the optical fibers, since they are rigidly mounted to the surfaces of the counters. It was also necessary to exercise caution to avoid entangling ropes with each other and with the various cables that were connected to the counters.

Since the cables and ropes are fairly exposed, and pulling on either can not only damage the light fibers, but also move the detector out of position, signs were placed at each corner warning people not to disturb the ropes or cables.

B. High Voltage

HV cables were connected to the patch crate as described in [1].

For high voltages, scintillation counters were split into 2 groups of 4 each. One group consists of the counters on the east-side bottom (216N, 216W, 236N and 236W), while the other group consists of the counters on the west-side (215N, 215W, 235N and 235W). Voltages for the new C-Hole scintillation counters are, as for other counters in the Central Scintillation System, controlled with the Muon HV gui. The 100% operating voltage value is the average of the nominal voltages, rounded to the nearest factor of ten, for the 4 counters determined in pre-installation testing.

215N,W, and 235N, W are controlled by SA44 on the Muon HV gui. 216N,W, and 236N, W are controlled by SA43.

C. Signal Cables

Cables for counters on the east side of the detector are connected to SFEs in crate 56, while cables for the west-side counters are connected to SFEs in crate 55. The addresses are given in [1].

TABLE II: Final nominal voltages measured for all counters using radium source method

	Counter	PMT A(V)	PMT B(V)	Average voltage
octant 5	215N	1998	2057	
	235N	2032	2086	
	215W	1983	2066	
	235W	2047	2066	2040 V
octant 6	216N	1971	1965	
	236N	1904	1989	
	216W	2143	2117	
	236W	2097	2086	2030 V

D. Optical light fibers

Existing Light Mixing Boxes (LMB) mounted on PDTs 205, 245, 206, and 246, already contained spare light fibers, but they were not long enough to reach the counters in their final positions near the detector centerline. Extension light fibers were used to provide the extra length to connect the spare light fibers to the new counters.

Prior to detector installation, the extension fibers were tested to ensure low signal losses. Spare fibers were also tested to find the fibers with the highest signal amplitudes.

The extension light fibers were connected to the scintillation counters prior to sliding the counters under the DØ detector. As noted earlier, great caution was required to avoid damaging the light fibers. After detector installation, the fibers were connected to the spare fibers coming from the LMBs.

Four spare fibers were used from each of the four LMBs, as shown in Table III.

In the event that light fibers need replacement, there are spare fibers still available for each of the 4 LMBs. For all but one of the four sets of counters (which one?), there is one spare coiled up and stored with the set of light fibers that run from the LMBs to the new hole counters. Additional spares may also be found attached to the 9 counters associated with PDTs 205, 215, 206, and 216, but these counters are not easy to access.

Spare extension fibers are stored in the Northeastern University storage locker.

TABLE III: C-Hole counter and PDTs on which LMBs containing spare light fibers are mounted

C-Hole counter	PDT
215N	205
215W	
235N	245
235W	
216N	206
216W	
236N	246
236W	

E. Problems encountered during installation

Some difficulties were encountered during installation. Since these same difficulties may be experienced again if these counters are removed for maintenance, they are listed briefly here.

•A unistrut frame on the south side was found to be making contact with metallic support shims. This is undesired because of the possibility of detector grounds, so it was necessary to place insulating sheets of G10 between the unistrut frames and the shims.

•Mechanical interference between the unistrut frames and these same support shims prevented optimal positioning of the detectors. Measurements taken of detector positions were used to correct geometry files.

•During installation of counters 215N and 215W, a small metal obstruction was encountered protruding out of the floor. It is believed to have been a marker used for surveying the D0 detector supports. This was removed with a hacksaw blade mounted to a long steel bar. Because a very small piece of the obstruction remained, it was necessary during detector installation to put a small piece of G10 between the counter and the floor to get the counter over the obstruction.

•A similar obstruction was found where 216N was to be installed. This obstruction was removed prior to installation.

•During installation, it was necessary to leave counter 215N on the floor for some testing.

It was discovered that someone not involved in the installation inadvertently stepped on the counter. After this, signs were made warning people not to step on the counters. The area was roped off when it was found necessary to leave the counters exposed on the floor for extended periods of time.

IV. POST-INSTALLATION TESTING

Immediately after installation, daq-local runs were done to ensure proper operation of the counters for light pulses generated using the LED pulsing system. This test verified proper operation of PMTs and the readout of the PMT, but is not by itself a complete test of the counter. Further studies will be done once the counters have been added to the trigger.

[1] H.T. Diehl, DØ Note 4088, January 25, 2003.